# Actively Detunable 8-channel Small Animal Transceive Volume Array for 9.4T MRI systems

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**Introduction** Ultra-high field MRI systems for small animals have seen a rapid development over recent years in a continuous effort to enhance SNR and spectral resolution of MRI images. To circumvent the associated high-field $B_1$ inhomogeneity problem, methods such as RF shimming and Transmit SENSE have been proposed [1-2]. To benefit from the advantages of these techniques, dedicated phased-array coils with spatially varying transmit-sensitivity of the array elements are essential. Each element of the phased array coil can be driven by an independent RF channel with an individual excitation profile. In the combined use of a volume array coil and a surface coil for RF transmission and signal reception, respectively, the transmit coil must be electronically (actively) detuned from the Larmor frequency during signal reception. Analogously, the surface coil must be actively detuned during RF transmission for signal excitation. In this work we discuss the development of a 9.4T, 8-channel actively detunable small animal transceive volume array, capable of operating in transmit and/or receive mode. All individual coil elements are actively detunable for operation with independent receiver coils. A prototype was constructed and tested in a Bruker 9.4T Biospec MRI system. Experimental results presented herein demonstrate the potential of the design.

**Methods** Depicted in Fig.1 is the equivalent electrical schematic diagram of the proposed design (only 3 coil-elements are shown). The active detuning circuit consists of a PIN-diode and biasing circuitry and can easily be implemented into each coil element of the array. This detuning circuit is controlled via an external Coil Control Unit (CCU). The coil element design was based on the angularly-oriented coil blade technique [3-4] and 'sandwiched' radiating structure [5] described in our previous work. On average isolation of -18dB between individual coil elements was achieved using a counter-wound inductor decoupling network [3]. In Fig.2 the volume array is shown with an 8-port coil control circuit and Tx/Rx switch, interfacing the coils to the RF transmitter and receiver paths of the MR system. Every coil can be tuned and matched for optimum performance with different loading conditions. A 4-channel receive-only surface array is also shown. All measurements were performed with a 9.4T 30cm BioSpec-system (Bruker BioSpin MRI GmbH; Ettlingen, Germany) equipped with eight transmit/receive channels. Each channel of this TX/RX-switch is equipped with low noise pulse-protected preamplifiers ($R_{input}$=50 Ω, NF=0.6 dB, gain 22 dB). Every TX- and RX-channel of the whole system could be controlled independently; all combinations of the coil-elements for transmitting and receiving during the MR-experiment were possible.

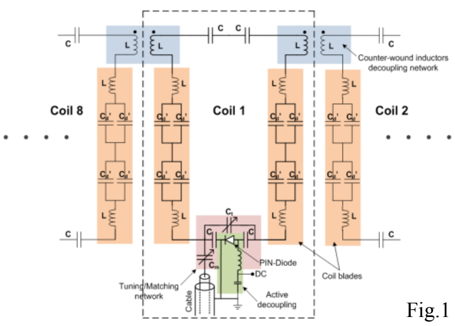

Fig.1

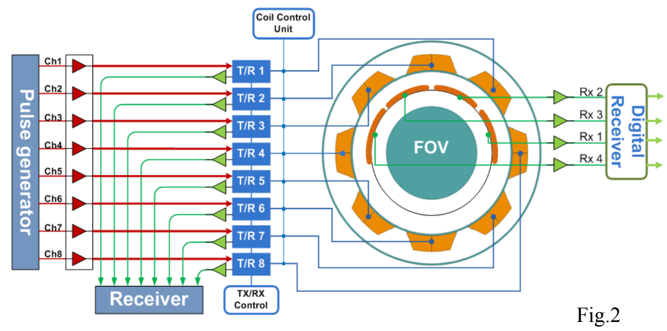

Fig.2

**Results** The prototype transceive volume array system was tested in combination with a receive-only surface coil. Shown in Fig.3a is the $B_1^+$ map of each coil element of the volume array. Fig.3b is the acquired sum-of-square MR image of a homogenous cylindrical phantom (125ml $H_2O$, 2g/L $CuSO_4$, 4.3g/L NaCl) with all 8 elements transmitting simultaneously in a birdcage-like excitation mode, with a 45° phase shift between adjacent coil elements, and receiving in parallel. Using cross-coil operation (Tx: 8-ch volume array, Rx: 4-ch surface array) with a FLASH imaging sequence, images of rat abdomen were acquired (*post-mortem)* as shown in Fig.4a. Depicted in Fig.4b is the SoS MR image of the phantom acquired by the 4-element surface array, birdcage mode excitation was used with the volume array in this instance. Fig.5 is a designed checker box image acquired using Transmit SENSE with reduction factor of 7 and 8. With cross-coil operation using the volume array and a 1-ch quadrature surface coil, images of cherry tomato were obtained, as shown in Fig.6. Parallel excitation mode (transmit SENSE) of the 8-channel volume array using spatially selective excitation was also tested and the obtained zoomed-images of the cherry tomato are also shown in Fig.6.

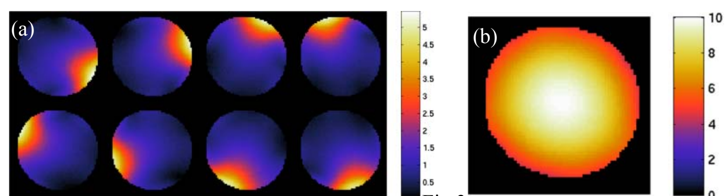

Fig.3

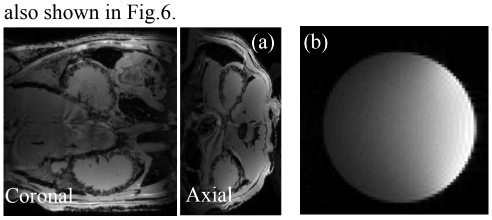

Fig.4

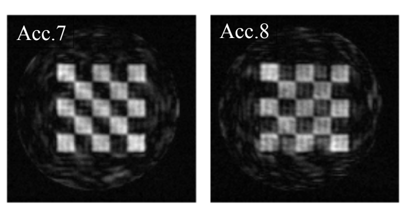

Fig.5

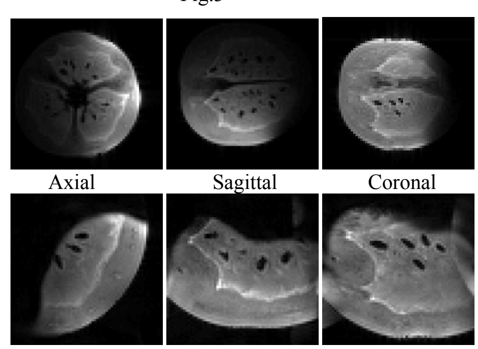

Fig.6

**Conclusion** In this work, a dedicated 8-channel actively detunable transceive volume array for small animal MRI applications at 9.4T was developed. Adding active detuning circuitry to all coil elements of the transcieve volume array extended the range of possible imaging applications beyond conventional cross-coil operation, where classical birdcage volume coils are normally used. The images obtained using different receive-only coils and a variety of loading samples showed no evidence of residual coupling in either transmit or receive mode of the experiment. This is a good indication that the proposed design is stable and robust

**References**
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